BULLETIN 1007A

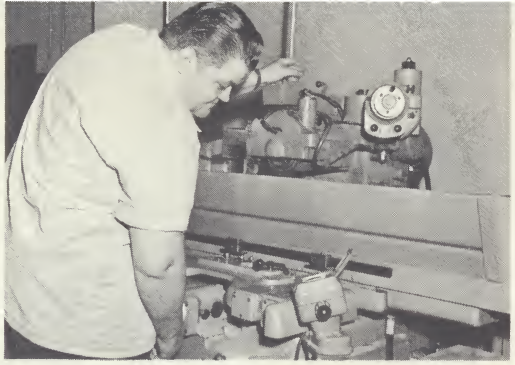
FERROXCUBE™
ALL-GLASS-BONDED
FERRITE MAGNETIC RECORDING HEADS

FLYING DIGITAL (DRUM/DISC)—highest packing density . . . lowest cost/bit; hence lowest system cost . . . lowest relative access time.

CONTACT DIGITAL—longest life; hence lowest cost/track/year . . . highest resolution . . . highest track density . . . highest signal/noise ratio.

CONTACT ANALOG—widest bandwidth . . . highest signal/noise ratio . . . lowest cost/track/year.

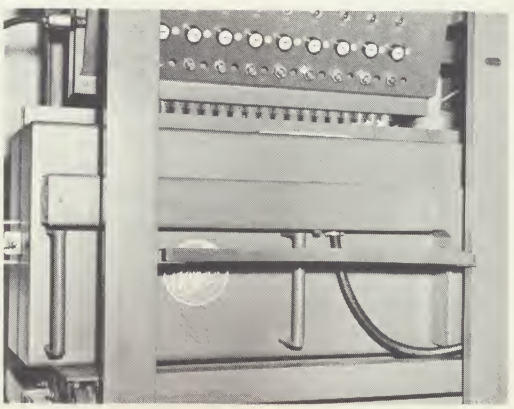
Precision Grinding of Pole Pieces . . . Ferroxcube ferrite facilities are unequalled anywhere in the world.



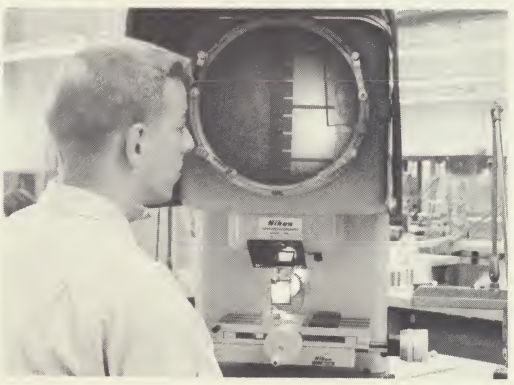
Precision Winding . . . Ferroxcube's modern winding facility employs the most modern fine-wire winding features and techniques currently available.

Quality-Assured Precision Assembly . . . Ferroxcube's new assembly line operates under the most rigid quality controls in the industry—from the ultimate security of 100% in-plant manufacture of all critical elements to the maintenance of "white-room" environments for all critical assembly operations.

Unique Glass Bonding Facility . . . Ferroxcube's all-glass-bonding technique is an exclusive patented process.



Micro-Finish and Testing Ferroxcube has developed completely new micro-finishing techniques compatible with the new higher dimensional-control standards made possible by all-glass bonding, and testing techniques, compatible with the 1.7 microinch RMS surface finish achieved on all standard heads.



LESS THAN TWO YEARS AGO, at this writing, Ferroxcube introduced a revolutionary new approach to the construction of precise magnetic recording heads for sophisticated data systems. In essence, it permitted the designers of digital and analog data recording systems to discard the then-current standards of performance and economy, providing significant improvements in both.

IN THAT BRIEF PERIOD, the new principle—called **all-glass bonding***—has been tested in dozens of different classes of magnetic recording applications, and has been put into successful large-scale production.

THE CLEAR-CUT SUPERIORITY of this unique design approach sets it apart from every alternative means of producing a high performance magnetic recording head, in all major areas of application; digital and analog, contacting and non-contacting.

*The all-glass-bonding technique is an exclusive Ferroxcube process, protected by U.S. & Foreign patents, granted and pending.

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APPLICATION ADVANTAGES

THE FIVE FUNDAMENTAL CHARACTERISTICS described below are all inherent in the all-glass-bonding technique. These five characteristics make possible five corresponding areas of application superiority, examples of which are annotated accordingly . . .

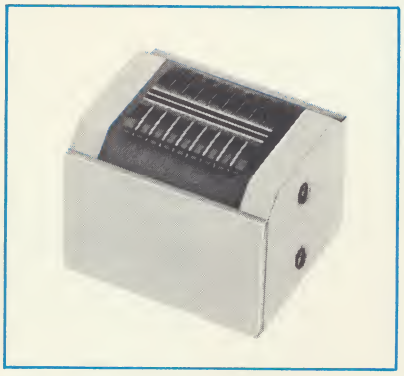
GREATER DIMENSIONAL CONTROL. Every significant dimension of an all-glass-bonded magnetic recording head may be controlled to a markedly higher accuracy than is consistently achievable in any other construction. Not only may these dimensions be controlled more accurately, and maintained at a consistently high accuracy from head to head and from lot to lot, but the minimum dimension achievable and controllable is *smaller* than in any other construction.

The dimensions of the flying heads for a large disc memory are so accurately controlled, for example, that the designers were able to specify a gap-length of 200 microinches and a flying distance of 100 microinches, making possible a packing density of almost five times that previously considered a maximum with conventional heads!

FAR GREATER DIMENSIONAL STABILITY. Not only can the dimensions of an all glass bonded recording head be controlled more accurately, but they exhibit comparable stability . . . thus making the dimensional control meaningful and useful. Because the ferrite pole-piece material used in these heads has essentially the same coefficients of expansion as the glass bonding material to which it is fused, and because the bonding process creates a single, mechanically-homogeneous structure, neither temperature nor mechanical stress, such as shock or vibration, can cause significant alteration in the critical dimensions upon which recording accuracy depends. The same thermal compatibility is maintained between the bonded track and its supporting structure.

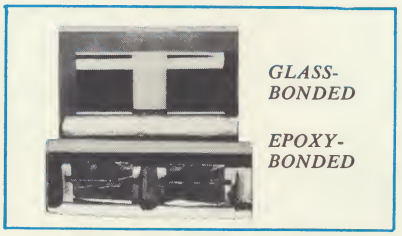
This 7-channel Read-Write contact analog tape head has such excellent stability that no variation in either reading or writing sensitivity is observable over the entire range of "MIL-Grade" ambient conditions encompassed within the standard IRIG environmental specifications.

MICRO-MACHINABILITY. It is possible to exploit fully the inherently high dimensional accuracy and stability, and the high-density homogeneity of the unique Ferroxcube 4R5 Ferrite formulation of the all-glass-bonded head because the hybrid surface formed by the unique Ferroxcube technique lends itself to precision micro-lapping . . . and the superb surface finish that is ultimately achieved is as flat as it is smooth, and almost impervious to wear, by conventional standards.



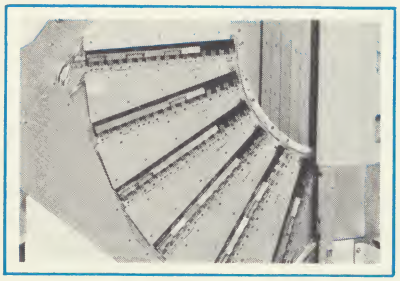
In this 7-track digital head, for example, the standard final finish is held to 1.7 microinches RMS and this finish is maintained to within 2 microinches over thousands of hours of use, despite the highly abrasive properties of the recording surface, which would literally destroy all dimensional control in a conventional epoxy-bonded laminated core design, in the same period of time. Further, all-glass-bonded heads do not suffer from the "build-up" of iron oxide particles on the head surface—an unavoidable and annoying feature of epoxy-bonded heads, caused by the affinity of the epoxy binder used in the tape formulation for the epoxy used to bond conventional heads.

IMMUNITY TO WEAR. We don't know exactly how long an all-glass-bonded contact head will last, under normal operating conditions. We *do* know, however, that in objective comparative tests, we are unable to measure any perceptible wear on an all-glass-bonded head, at the time that a conventional epoxy-bonded head *reaches the end of its useful life.*



In typical computer tape transportation services, for example, a large user estimates that conversion to all-glass-bonded heads from conventional cast-epoxy designs, saves the total cost of the conversion every five months, in an average installation employing 40 read/write heads!

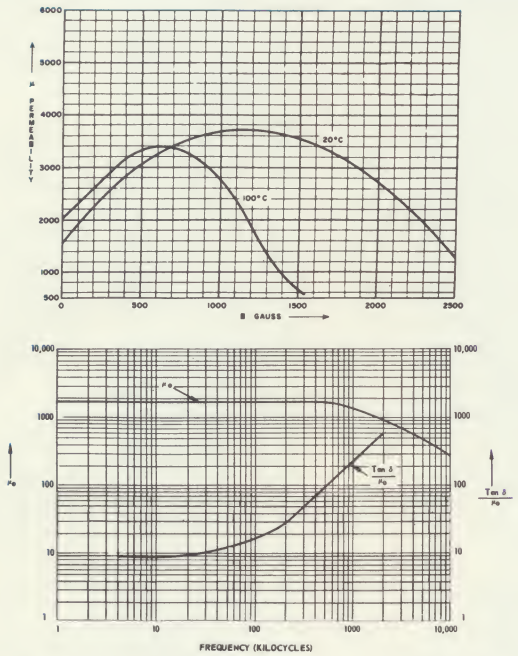
DESIGN FLEXIBILITY. Because the all-glass-bonding technique employs a high performance ferrite material, and because it is not limited to any particular size or configuration of track, the designer is given far greater freedom in specifying the recording format he wishes to employ. Both the gap spacing and the head spacing may be varied over wider ranges using this technique, than has ever been possible with conventional designs.



On each disc face of this General Precision/Librascope L-4000 Disc File, there are 432 Read/Write heads counted, mounted 12 (plus a spare) per bar, 6 bars per radial column, 6 columns per disc face. Track and bit density are at "state-of-the-art" highs made possible by the Ferroxcube all-glass-bonded head design.

DESIGN PARAMETERS

FERROXCUBE 4R5 is the recording-track material used in all-glass-bonded recording heads. It is unique in having chemical, thermal, and mechanical characteristics that are fully compatible with the special glass used to bond the head assembly; this unique formulation sacrifices very little in either its electrical or magnetic properties to achieve that compatibility. As the chart below shows, 4R5 has excellent permeability and extremely low residual retentivity. Its losses are negligible in most applications, over a wide frequency range. Note that the parameters given in the chart below are accurately controlled to insure uniform electrical performance.



Initial permeability (μ_o) of new Ferroxcube 4R5 material is uniformly high, loss is remarkably low, over a wide frequency range.

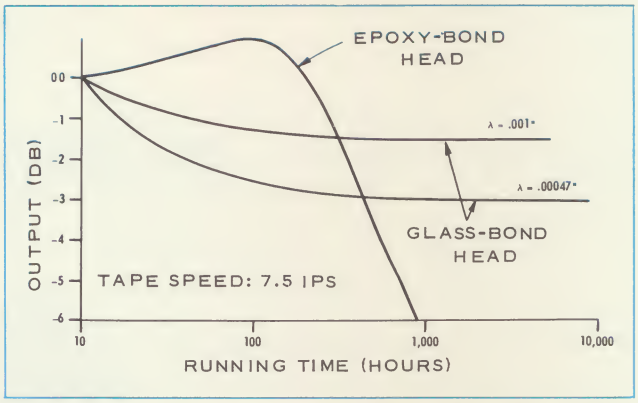
SURFACE CONTOUR AND FINISH. As noted earlier, the final, bonded head structure is readily machine-finished. The final contour of the head may be specified to a tolerance of **±0.0005″;** and its flatness to 2 light-bands; and its surface finish may be specified to better than 2 microinches. While this precision is not required in many applications, the fact that it is obtainable in standard heads adds a comfortable margin of reliability and uniformity to the performance of these heads in less demanding applications.

MECHANICAL INTEGRITY. Ferroxcube recording heads have a high molecular density (99.8% of theoretical monocrystalline density) extremely high rigidity (Young's Modulus equals 21 x 10^6 psi) extreme hardness (Rockwell C-66) and are almost impervious to either mechanical impact, shock or sustained vibration. (In this regard, it is interesting to note that a standard all-glass-bonded design has sustained an impact shock of over 175 G's, without deterioration or significant change in performance characteristics!)

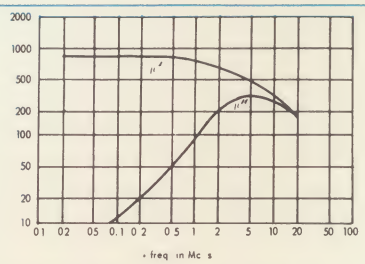
ENVIRONMENTAL IMMUNITY. As mentioned earlier, the expansion coefficients of the glass, the ferrite material, and the supporting structure are so carefully matched that the bonded head is not affected by extremes of temperature or temperature gradient, despite repeated thermal shock or extended cycling.

The all-glass-bonded structure is equally impervious to humidity, or any other hostile atmosphere, such as corrosive fumes, fungus, or airborne particles. The active gap in the finished head is completely encapsulated in a hard, inert film of glass, and can withstand almost any military or industrial environment without significant deterioration, despite prolonged exposure.

WEAR RESISTANCE. As mentioned earlier, complete life test data are not yet available on Ferroxcube all-glass-bonded recording heads, because the amount of wear observed even under severe operating conditions, has so far been too small to measure or correlate significantly. Some idea of the probable life expectancy of a contact head operated at a high speed, may be obtained from the chart below. Note that the "control" sample, a epoxy-bonded head of conventional design, fails completely and catastrophically before a measurable change is observed in the performance of the all glass bonded sample.

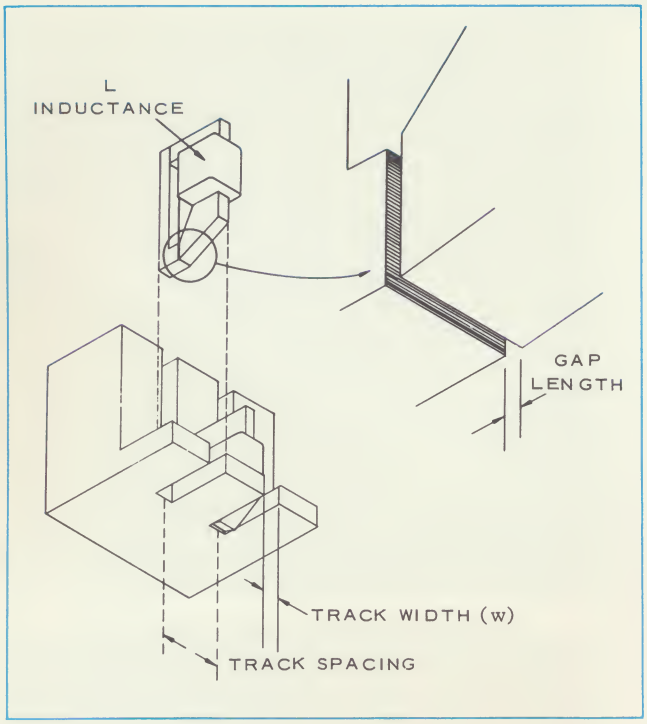


ELECTRONIC COMPATIBILITY. The electromagnetic performance of all-glass-bonded recording heads is, in the limit, somewhat superior to that of heads designed with more sensitive Ferroxcube ferrite core material—because the gap-to-gap separation may be made so much smaller for the all-glass-bonded head. With comparable spacing, it may be necessary to accept slightly lower sensitivity, although other parameters, such as bandwidth and "Q", will be somewhat improved. In general, our application engineering department can show you how to duplicate or improve upon the electromagnetic performance of any conventional recording head without modifying the system into which the all-glass-bonded head is to be installed, by making appropriate internal alterations.



Real part (μ′) and imaginary part (μ″) of initial permeability, plotted as a function of frequency for Ferroxcube 4R5.

DESIGN SPECIFICATIONS



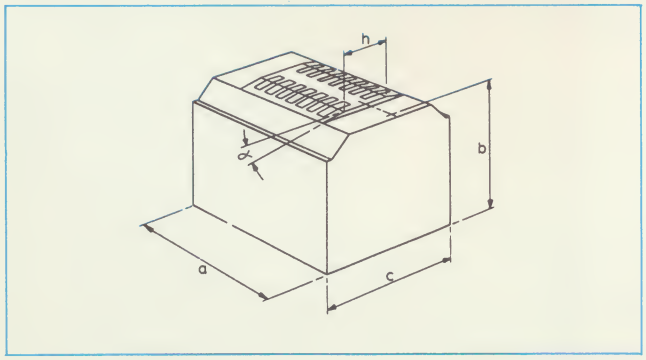
FUNDAMENTAL DIMENSIONAL RELATIONSHIPS. The drawing to the left indicates the fundamental dimensions that determine the performance—and, hence, the design—of a "flying head". Note that the relationships between these critical dimensions and the head performance is given by

Read-out voltage = k_1nwv
where n = number of turns per winding,
w = track width,
and v = velocity.

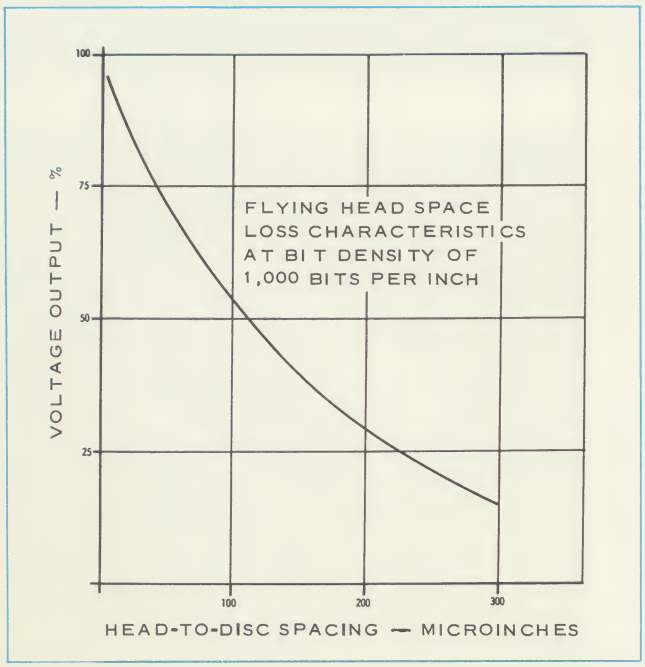
Inductance $L = k_2n^2w$

Drive current = $\frac{k_3h}{n}$

HEAD-TO-HEAD DIMENSIONAL RELATIONSHIPS. Not illustrated, but equally as important as the fundamental head-to-medium relationships, are the dimensions and tolerances that relate one head to another in a multi-head assembly. These include: head *spacing* (distance between gap centerlines); head *separation* (distance between facing magnetic surfaces of adjacent cores); track width; gap length; and, of course, at least an estimate of gap alignment requirements. Tolerances must be applied to all of the data listed above.



READ-TO-WRITE RELATIONSHIPS. As illustrated to the left, certain dimensions and tolerances must be applied to multiple-head assemblies in which the read/write function is provided—whether in a unit assembly, or in a pair of assemblies. Note that this set of specifications is actually derived from the **basic data format** planned for the system.



GAP CHARACTERISTICS. As illustrated to the left, a complete head specification must include some data relating the head-to-medium geometry to the effective *flux geometry*. One way to do this is to specify the contour and dimensions of the core gap; an easier (and more secure) way is to describe the static and dynamic head-to-medium spatial relationships, specify the limiting electromagnetic properties of the recording medium, and describe the input-output signals and circuit interfaces . . . and let Ferroxcube Application Engineering assume the responsibility for satisfying the stated requirements.

"TRADE-OFFS" TO OPTIMIZE DESIGN. If Ferroxcube Applications Engineering is brought into the design effort early enough, it may be able to suggest alternative specifications that will optimize one or more inter-dependent parameters, at the expense of less critical characteristics. Typical of such "trade-offs" are:

Crosstalk vs track-to-track spacing.
Resolution vs signal output amplitude.
Flying distance vs signal output amplitude.
Inductance vs drive current.

TYPICAL DESIGNS

FLYING HEADS (Digital) for the Librascope L-4000 Series Large-Capacity Disc Memories Assemblies of 13 heads ride on an air cushion only 0.0001″ thick. This close gap-to-medium spacing permits greater "packing" and narrower track width than ever before achieved in this class of storage device; hence Librascope was able to provide remarkably fast access, despite state-of-the-art data density.

13 Track Recording Head Assembly

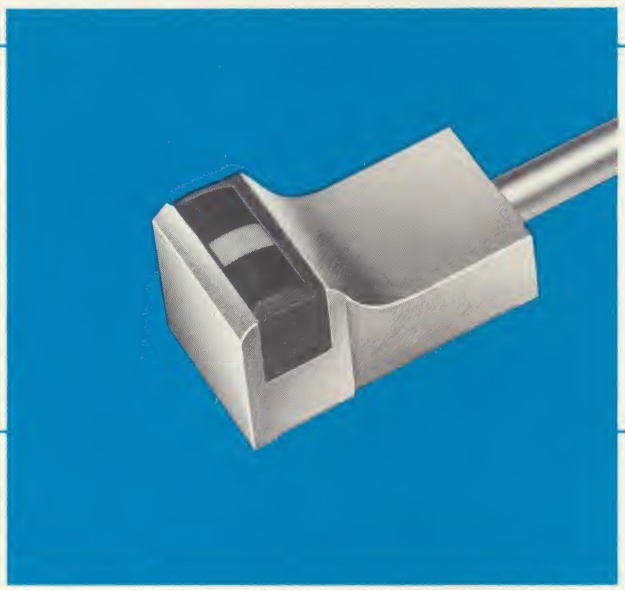
1.60 −272 +00

Gap Length:	400-500 a″	
Track Width:	.014-.0145	
Gap Scatter:	±.003	
Flatness:	:Convex 3 Concave	0 Direction of Flight
Inductance:	130 ±10%	
Number of Turns:	40 (Bifilar)	
Size of Wire:	43 AWG.	
RMS (Pads):	4	
Final Gap Height:	.010-0.12	
Case Material:	FXC 3	
Head Material (Pole Piece):	FXC 4R5—glass-bonded	

CONTACT HEADS (Digital) for a "Magnetic-stripe-reader" for check-readers, ledger-processing equipment, and other business-machine applications.

Standard Single and Dual-Track Heads

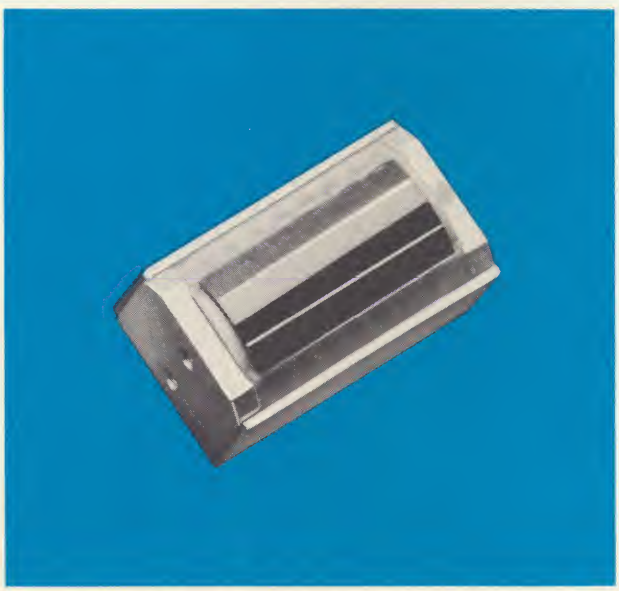
Gap Length:	0.001 inch
Track Width:	0.250 inch
Track Spacing:	0.400 inch c/c
Inductance: (center-tapped)	80 mH
Gap Scatter:	<100μinch
Angle (∝) Tolerance:	±15 minutes



CONTACT HEADS (Analog) for an analog tape transport with state-of-the-art bandwidth and signal/noise ratio.

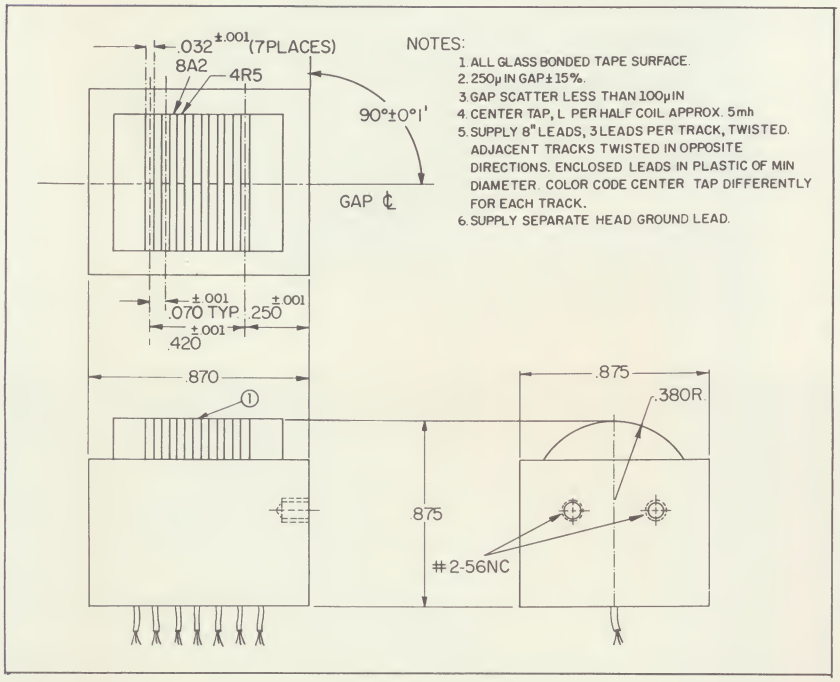
TYPICAL ANALOG HEADS

	Eight-track, write (1in tape)	Eight-track, read (1in tape)	
GENERAL			
No. of tracks	7 + 1	7 + 1	
Track width	0.5	0.5	mm
Gap length	3 to 4	1 to 2	μm
Self-inductance at 100kc/s	0.1	2	mH
Resonance freq.	14	1	Mc/s
TEST CONDITIONS AND PERFORMANCE			
Tape speed	150	150	cm/s
Tape tension	150	150	g
Oxide coating thickness	6	6	μm
Bias current	65	—	mA
Write frequency	40	—	kc/s
Write current (pk-pk)	16	—	mA
Output voltage (pk-pk)	—	3	mV
Maximum crosstalk			
read-read	—	−42	dB
write-write	−44	—	dB



SPECIFICATION CRITERIA

THE BEST WAY TO EVALUATE THE advantages afforded by Ferroxcube recording heads is to consider at least a preliminary proposal on a **specific** requirement. Here's a convenient, 10-minute way to obtain a specific engineering proposal . . .



You may find that one of our existing designs is sufficiently similar to your requirements so that you can evaluate the advantages of the all-glass bonded technique without requesting a specific proposal from us at this time. This "library" of specification control drawings and data sheets has been assembled for that purpose.

FIRST give us some idea of the type of head and its intended application. (Check the type of head, the class of operation, and fill in the number of heads per assembly and the total quantity of assemblies that will probably be required for your project. _____

THE NEXT most important consideration is the "mix" of chacteristics that should be favored, in developing an optimum design. (See page 3 for a discussion of the performance criteria and the examples given of optimized performance mixes achieved by "trade-off".)

If this design is to supplant an existing conventional design (cast epoxy, laminated, and encapsulated, etc.), please give us some idea of the important geometric relationships that must be respected in producing a new design. We have indicated, in the sketch below, the kind of information that would help us make a meaningful proposal.

Indicate, by numbering the criteria listed here in their relative order of importance. (If two or more criteria are equally important, assign them the same number.) _____

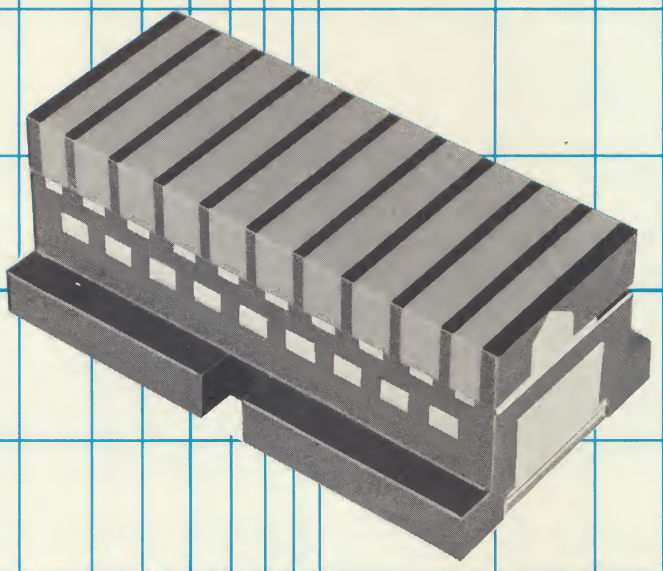
SKETCH the critical geometry that governs the design in this space, if possible. (Indicate governing dimensions, and any other details that must necessarily be duplicated.) _____

ALTERNATIVELY, you may wish to request a kit of typical recording-head designs, and specifications for them, which we have prepared for evaluation purposes. Indicate here the number of these kits that you wish, for you and your colleagues, and we'll be happy to send them along, by return mail. _____

THEN, if you please, tell us a bit about yourself and your role in the design function in your company. _____

AND give us some idea of the current activities and interest of your department or division. _____

NEED EXTRA COPIES of this brochure for your colleagues? . . . Certainly, just indicate how many you want, or give us the name or names to whom you wish them sent. _____



EVALUATE FERROXCUBE RECORDING HEADS IN TERMS OF YOUR SPECIFIC NEEDS
with this convenient "pre-specification" reply card, to receive a detailed preliminary proposal.
. . . or call your nearest FERROXCUBE Sales Office, listed below.

FERROXCUBE
CORPORATION OF AMERICA

MAIN SALES OFFICE
Saugerties, N. Y.
Telephone (914) 246-2811
TWX: (510) 247-5410

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New York—Park Square Building, Room 322, Morristown, N. J.
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ATTENTION
RECORDING-HEAD
APPLICATION
ENGINEERING
DEPARTMENT

Gentlemen:

MAGNETIC RECORDING HEAD SPECIFICATION

Head Type

☐ Contact ☐ Digital ☐ Writer ☐ Flying
☐ Analog ☐ Reader. ☐ Writer/Reader

Production Requirement

Number of Heads per Assembly _____

Total Number of Assemblies _____ /yr.

Recording Medium:

☐ Drum ☐ Disc ☐ Tape ☐ Magnetic Ink
☐ (Other) _____

Surface Speed or frequency range

_____

Signal Data (Include Noise Level or S/N ratio):

Read Signal: _____

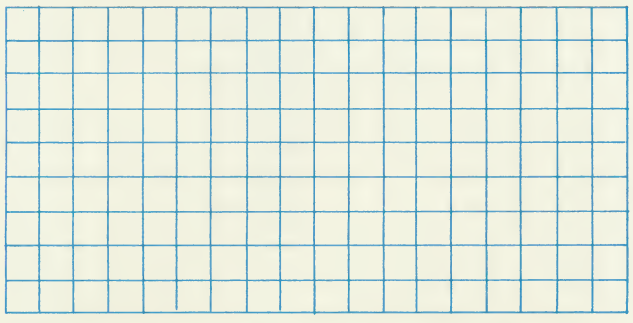
_____ Write Signal: _____

_____

Relative Importance of Design Characteristics:

____Tracks per inch (min.___)
____Bits/inch (min.___) or
____ Bandwidth (___to___ ± ___ db)
____Track width
____Head spacing
____Gap Length
____Gap Scatter
____Contour (Tolerance___)
____Inductance per head (___)
____ Q per head (___)
____Flying Distance
____Environment
____Temp. Range:
____Shock:
____Vibration:
____Humidity:
____Crosstalk
____Output Amplitude
____Resolution
____Drive Current

Head Geometry and Mechanical Tolerances



☐ Send the Ferroxcube Recording Head Data File

NAME: _____

TITLE: _____

COMPANY: _____

DEP'T: _____

ADDRESS: _____

CITY: _____

STATE: _____ ZIP CODE: _____

Currently engaged in _____

_____

☐ I would like_____ additional copies of the Ferroxcube Recording Head Brochure forwarded to
☐ me ☐ the following:

NAME _____
TITLE

NAME _____

NAME _____